AN INTRODUCTION TO NATURAL FIBRE INSULATION

A CPD SEMINAR FROM THE ASBP AND
THE NATURAL FIBRE INSULATION GROUP

ASBP The Alliance for Sustainable Building Products

NATURAL FIBRE INSULATION GROUP

PART 1: THE BASICS

AN INTRODUCTION TO NATURAL FIBRE INSULATION

ABOUT US

The Alliance for Sustainable Building Products

- To champion sustainable building products for a healthy low carbon built environment

The Natural Fibre Insulation Group

- To further the understanding of the multiple benefits of natural fibre insulation products and systems

ALLIANCE FOR SUSTAINABLE BUILDING PRODUCTS (ASBP) MEMBERS

Over 50 members and supporters including architects, product manufacturers, specifiers, suppliers, contractors, research institutions and more…

NATURAL FIBRE INSULATION GROUP

NATURAL FIBRE INSULATION GROUP MEMBERS

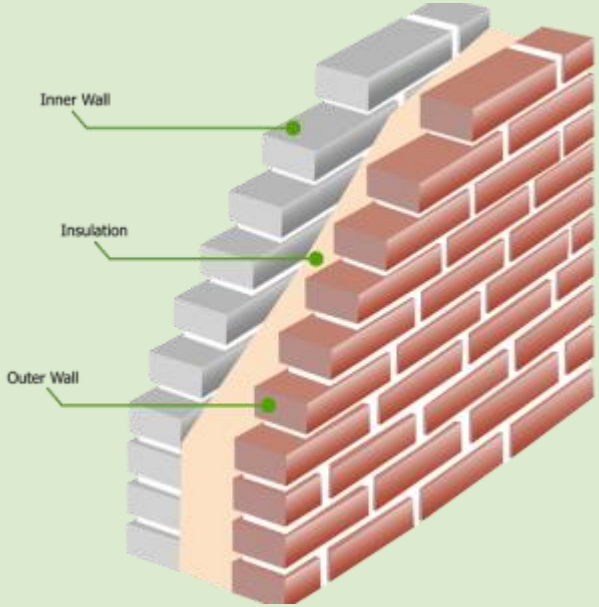
A group of ASBP members have come together to establish the Natural Fibre Insulation Group (NFIG) and through collaborative actions aim to better communicate the benefits of natural insulation products and systems.

NATURAL FIBRE INSULATION GROUP

A BIT OF CONTEXT

Insulating buildings is a relatively new idea

- From a regulatory perspective it begun in the 1970s and then was given rocket boosters in the 1990s.



A BIT OF CONTEXT

Like all things, insulation is rapidly evolving…

- …but it's not a new thing. Natural fibres have been used as insulation for 1000s of years.
- With industrialisation, straw and mineral fibre insulation developed. More recently the industry has been dominated by petrochemical foams where the innovation 'arms race' has been upon achieving the lowest rate of heat flow
- We are now understanding (remembering) that insulation influences building performance in multiple ways requiring a more sophisticated approach (e.g. fire, human health and comfort, moisture, durability, acoustics, buildability, environmental impact). Insulation is a multi-functional product
- We're increasingly understanding insulation not as a stand alone product but as being part of a construction element or system

NATURE'S BOUNTY

NATURAL FIBRE INSULATION PRODUCTS ARE PRODUCED FROM LOWER GRADE FIBRES OR LOW VALUE BY-PRODUCTS










NATURAL FIBRE INSULATION GROUP

NATURAL INSULATION TYPES

- RIGID BOARDS (WOOD FIBRE, CORK)
- FLEXIBLE BATTS AND ROLLS (WOOD, WOOL, HEMP, FLAX, COTTON)
- LOOSE (WOOD, CELLULOSE)
- BALES (STRAW)
- PANELS (STRAW)
- CAST IN-SITU (HEMPCRETE)

MANUFACTURING PROCESSES

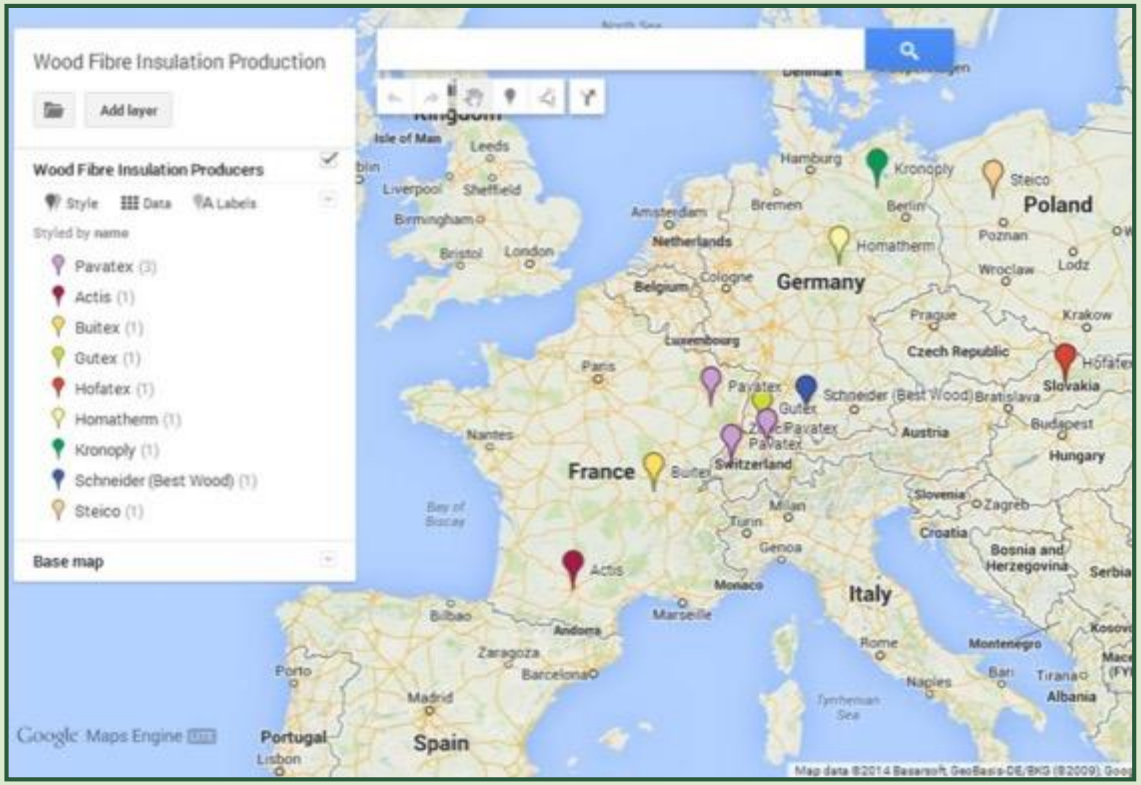
- **RIGID WOOD FIBRE INSULATION**
  Either wet formed (like paper making – no binder)
  or more recently dry formed (like MDF) with binder.
  No FR chemicals necessary

- **FLEXIBLE INSULATION**
  Produced in modified textile nonwoven process
  (typically with synthetic fibre binder and FR chemicals)

- **LOOSE CELLULOSE**
  (hammermilled newsprint with FR chemicals)

- **STRAWBALE AND HEMPCRETE**
  (Free from synthetic binder or FR chemicals)

WHERE IS NATURAL FIBRE INSULATION MADE?

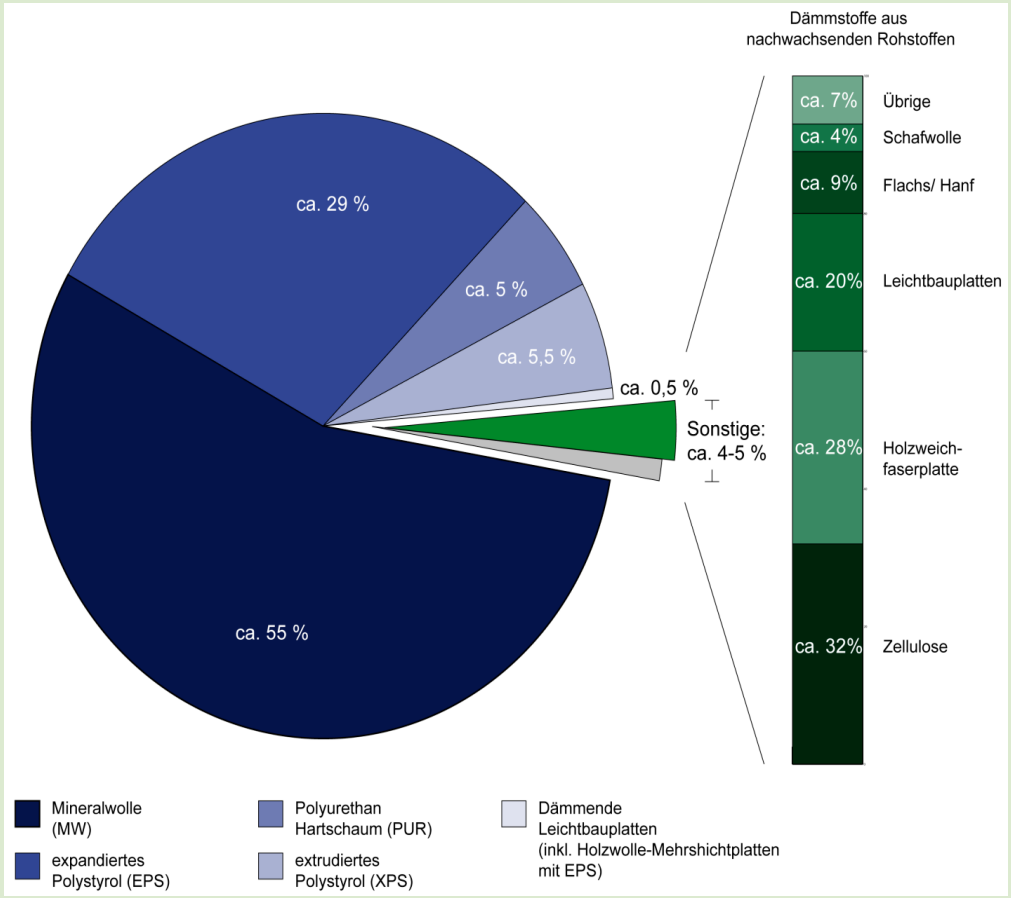


- Wood fibre (see map) insulation currently not manufactured in UK
- Wool and hemp manufactured in Dewsbury, UK
- Cellulose not currently manufactured in the UK

NATURAL FIBRE INSULATION GROUP

THE CURRENT SIZE OF THE MARKET

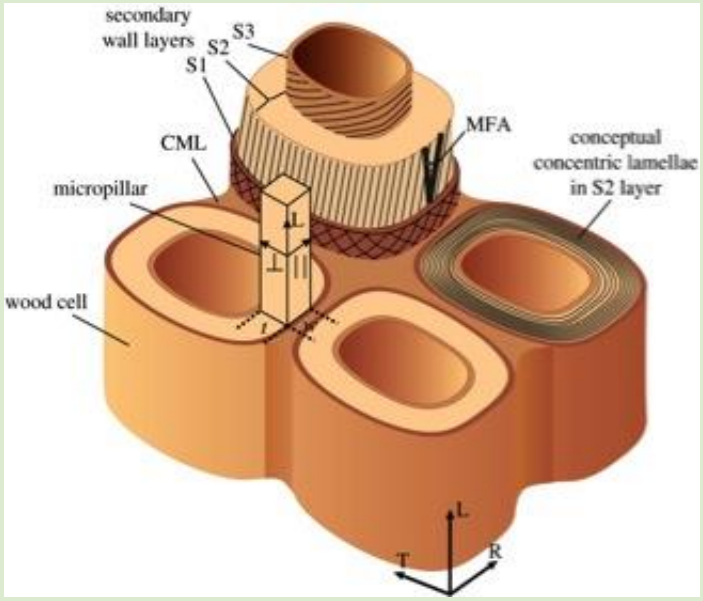
- Fraction <0.1% in the UK
- About 6% of the German market

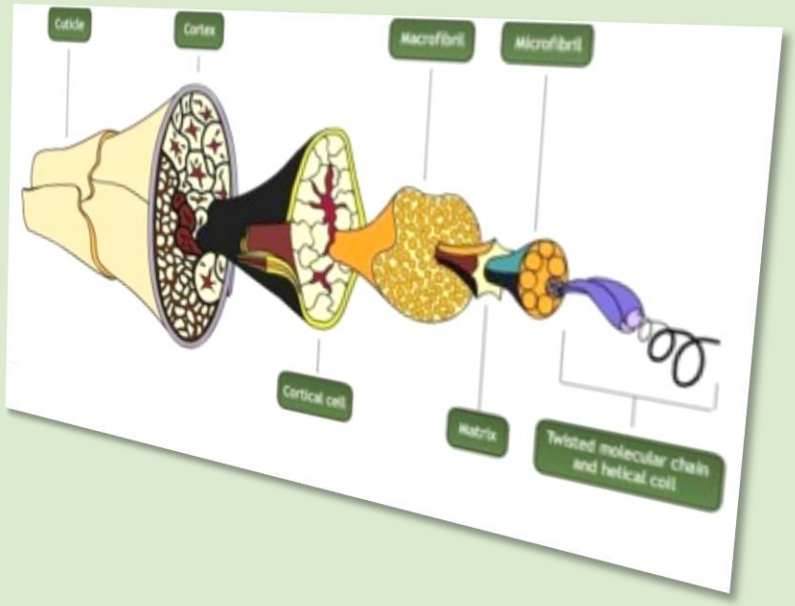


NATURAL FIBRE INSULATION GROUP

NATURAL FIBRES ARE COMPLEX

Synthetic fibres are relatively simple. Natural fibres are complex. It is in part this complexity that provides the secret to understanding the benefits of natural fibre insulation.





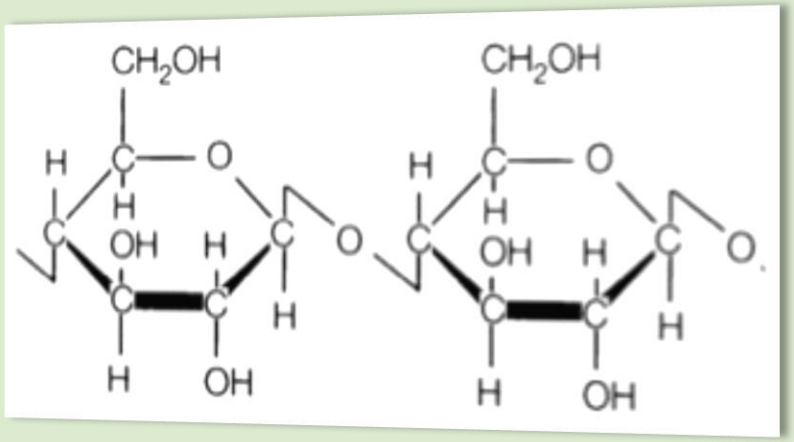
THE CHEMICAL STRUCTURE OF NATURAL FIBRE

- Carbohydrates: Cellulose, Hemi-Cellulose, Lignin
- Proteins: α-Keratin, ß-Keratin, Fibroin
- Energy of synthesis comes from the sun.
- All have a carbon backbone
- Insoluble, stable and strong
- Poor conductors of heat
- Low density
- All can bind and release water at a molecular level

NATURAL POLYMERS

- All contain “hydroxyl” groups (-OH) which enables hydrogen bonding.

- Hydrogen bonding is what enables natural fibres to bind individual molecules of water which gives them their characteristic breathability.



FIBRE BREATHABILITY

In order to be fully breathable a fibre must:

- Allow the passage of water as a gas.
- Be able to bind and release individual water molecules.
- Adjust its moisture content in response to changes in relative humidity of the surrounding air.

PART 2: CASE STUDIES

AN INTRODUCTION TO NATURAL FIBRE INSULATION

WOODFIBRE EWI

Ashfield Mews

- Lime render was sympathetic to adjacent period buildings
- For equivalent heat U-value, woodfibre insulation on a timber frame construction occupied a smaller footprint than traditional masonry
- Provides an envelope of rigid insulation to eliminate thermal bridges
- 100mm woodfibre boards were easy to install onto the stud framework
- Water vapour diffusion capability ensures dry walls without the risk of mould
- Excellent weather and rain protection due to high performance lime render system

EXTERNAL WOOD FIBRE BOARD - NEW BUILD

Passivhaus homes, Norfolk

- An affordable housing development of 15 homes in Norfolk.
- Achieved Passivhaus standards.
- 100mm wood fibre rigid insulation board installed externally over a 195mm deep insulated timber frame resulting in a U-value of 0.137 W/m2K.
- Wrapping the timber frame externally with wood fibre improves the U-value but also helps to minimise thermal bridging at floor junctions and around windows.

EXTERNAL WOOD FIBRE BOARD - RETROFIT

Houlston Manor, Shropshire

- 17th century solid wall house
- Leaks from wind driven rain due to failed pointing
- Externally insulated with rigid board wood fibre insulation
- Lime render finish
- Breathable material reduces risk of moisture condensation
- Improve weatherproofing and aesthetics
- Efficiency measures led to a 60% reduction in energy bills

INTERNAL WOOD FIBRE BOARD - RETROFIT

Victorian Terrace Refurb, Brent

- Complete refurbishment of a Victorian terraced house
- Internal wall insulation consisting of rigid wood fibre board on the front and flexible wood fibre wool on the rear of the board.
- Internal walls in pre-1930's buildings are usually uneven.
- This combination allows the board to mould itself to the shape of the wall surface, avoiding the need to render it flat first.
- The project achieved an 88% reduction in heating costs.

INTERNAL WOOD FIBRE BOARD - RETROFIT

Edinburgh Centre for Innovation

- Redevelopment of the 18th century former Royal High School.
- The primary structure, inserted within the atrium and to all new construction, is a Cross Laminated Timber frame (CLT) and CLT floor panels system
- Insulation is a combination of flexible wood fibre batts and rigid fibreboard with an OSB airtight layer internally.

FLEXIBLE WOOD FIBRE - NEW BUILD

New-build house, Inverness

- New build private dwelling in an exposed, changeable climate.
- 140 mm timber frame walls fully filled with flexible wood fibre insulation.
- Externally insulated with 80 mm rigid external wood fibre board with 15mm lime render.
- 140 mm flexible wood fibre insulation between rafters with 80 mm rigid wood fibre sarking board on top.

EXTERNAL WOOD FIBRE BOARD - NEW BUILD

Suscon Academy, Dartford

- The project was a mixed build of timber and concrete.
- Timber frame with concrete running through the “spine” of the building.
- Wood fibre rigid insulation board installed externally, with a render finish.
- Upon completion, achieved the highest ever BREEAM rating for an educational building.

STRAW BALE - NEW BUILD

Social Housing, North Kesteven

- World's first social housing scheme made from straw bales.
- Semi-detached three bedroom council houses in Waddington, Lincolnshire.
- Built for £103,000 per house.
- Needs no framework as made of load bearing straw.
- No cement in the build.
- Sheep's wool insulation to the roof and ground floor.

PRE-FAB STRAW BALE

EcoCocon project, Lithuania

- ECOCOCON is a producer of prefabricated straw panels.
- Combined with an interior clay plaster, and an exterior layer of wood fibre boards.
- Modular building system.
- Thermal resistance of the panels is 0,056 W/mK with a resulting overall **U-value of 0,107 W/m²K**(R=9.3), including the 100mm wood fibre board on the outside.
- C2C product innovation institute certified.
- Passive House Institute certified.

SHEEP'S WOOL - RETROFIT

Bodleian Library, Oxford

- 250mm sheep's wool insulation slabs installed between and over joists over an area of 500 m^2.
- The building was entirely re-roofed using copper with a lifespan of approximately 150 years.
- The existing timbers were in good condition and didn't need replacing.
- The insulation was easy to install within the uneven spaces of the roof.
- Natural fibre option provided a moisture buffer helping regulate humidity levels.

CELLULOSE - NEW BUILD

Passivhaus home, Kendal

- Two storey detached dwelling which has been certified to Passivhaus standards.
- Extremely low airtightness result of 0.11 air changes per hour at 50 Pascals.
- Timber studs full filled with loose cellulose fibre insulation made from recycled newspaper.
- Externally insulated with rigid wood fibre insulation boards.
- ‘Bob tail truss’ rafter roof has loose cellulose fibre insulation blown into a depth of 600mm giving a U-value 0.062W/m2K.

STRAW BALE & CELLULOSE - NEW BUILD

The Enterprise Centre, UEA

- Award winning education and office building which uses a number of locally sourced and natural materials.
- Achieved Passivhaus standards.
- 343 straw cassette panels used to clad exterior.
- The 340mm thick walls of the frame and 400mm deep roof were filled with cellulose fibre insulation from recycled paper.

CELLULOSE - RETROFIT

The Foundry, London (Our offices!)

- Retrofitted canal-side Victorian foundry refurbished into BREEAM Excellent offices.
- An inserted steel frame works with the existing 19th century frame and masonry to support the listed south wall and provide a double-height office mezzanine space with views onto the canal.
- The south wall's insulation has been upgraded to a u-value of 0.1W/m2/K by using recycled newspaper.

HEMPCRETE - RETROFIT

Grade II listed cottage

- Hempcrete installed as in-fill to oak timber frame
- Replaces inappropriate materials used in previous repair
- Prevents moisture being trapped within the wall build up
- Combination of insulation and thermal mass
- Excellent airtightness within frame
- Finished with lime plaster / render

JUTE - NEW BUILD

Log House, Northampton

- 200mm of Jute Insulation used in roof
- 100mm in stud wall
- Combined with a wind & weather tight T&G wood fibre board on roof with an airtight, intelligent membrane on the underside
- Hygroscopic with excellent diffusion properties
- High thermal properties (λ=0.038W/Mk)
- Excellent heat storage capacity (reduces overheating)
- Noise buffering material (high-density)
- Easy disposal and recycling

CORK - RETROFIT

2 bed cottage, Cumbria

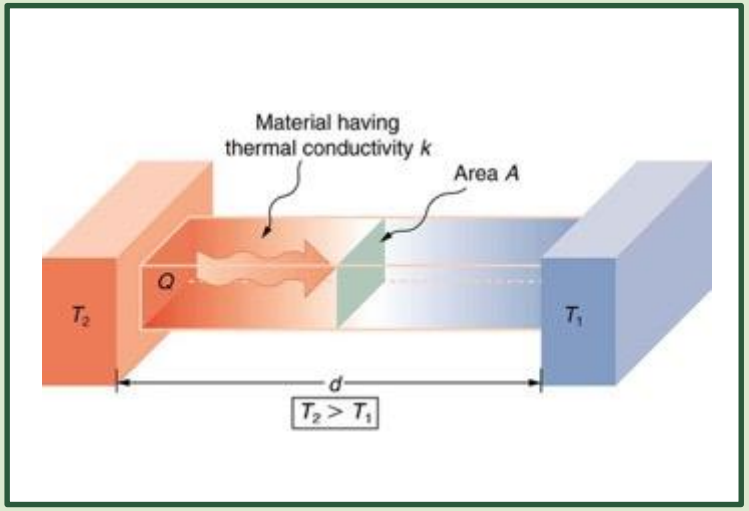
- Solid sandstone 500mm rubble walls
- Insulated Internally and externally with Cork Insulated Plaster (0.045 W/mK)
- A breathable, capillary active insulation
- No additional levelling coat required on to existing stone or brick
- Spray application of 2 layers of 25mm completed in 1 day
- A 3 time thermal improvement on the existing U value
- Finished with a smooth lime based render

PART 3: PERFORMANCE

AN INTRODUCTION TO NATURAL FIBRE INSULATION

IT'S ALL ABOUT…

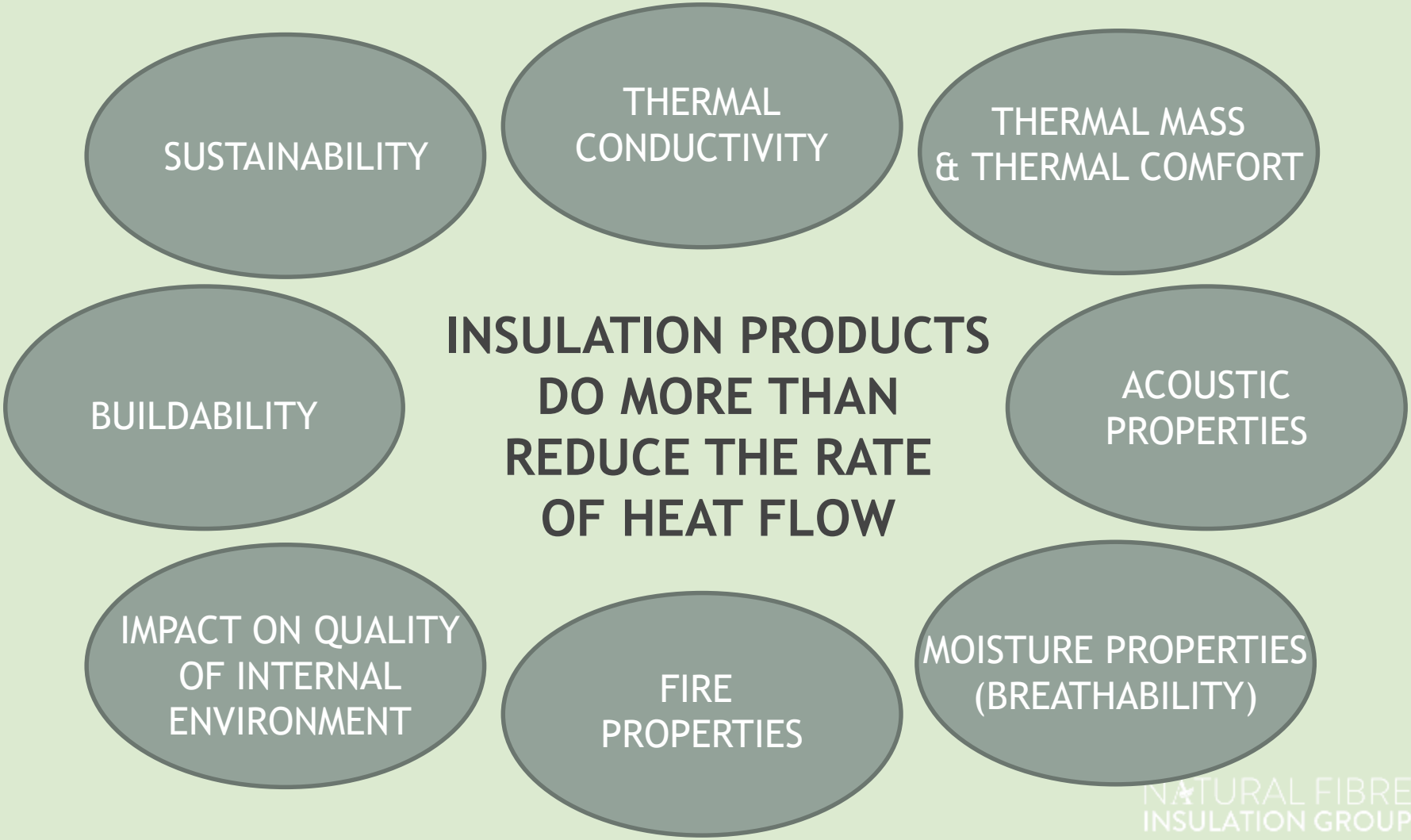
…the ***taste***



…the ***thermal conductivity***

Or is it??

BEYOND LAMBDA



NATURAL FIBRE INSULATION GROUP

SOME THERMAL CONDUCTIVITIES

Product	Thermal Conductivity (W/m.K)
Glass fibre (lofts)	0.043
Glass fibre (walls)	0.035
Glass fibre (walls)	0.032
Rockwool (32kg/m3)	0.038
Rockwool (60kg/m3)	0.039
PIR/ PUR	0.022
Flexible wood fibre insulation / sheepwool / hemp (25-55 kg/m3)	0.038 – 0.040
Rigid wood fibre (110 – 240 kg/m3)	0.038 – 0.047
Loose cellulose / wood fibre	0.039
Straw bale (90 – 110 kg/m3)	0.057 -
Hempcrete (200 – 500 kg/m3)	0.05 – 0.09

BUT ACTUAL FABRIC THERMAL PERFORMANCE ALSO DEPENDS ON……

- Real world dynamic (not steady-state) thermal properties
- Air tightness
- Workmanship
- Cold bridging
- Avoiding unintended negative impacts (e.g. trapped moisture)
- Fabric thermal mass (too high, too low or just right)

THERMAL MASS AND THERMAL COMFORT

Appropriate level of fabric thermal mass can provide:

- Overheating protection
- Help reduce internal temperature fluctuations

NATURAL FIBRE INSULATION GROUP

THERMAL DIFFUSIVITY

- ***High density, low thermal conductivity*** and ***high specific heat capacity*** results in an insulation product with a ***low thermal diffusivity***
- ***Low thermal diffusivity*** increases the time between the highest external temperature and the highest internal temperature)

Material	Density (kg/m3)	Thermal conductivity (W/m.K)	Specific heat capacity (J/kg.K)	Thermal diffusivity (cm2/h)
Rigid wood fibre	140	0.041	2100	3
Flexible wood fibre	50	0.038	2100	15
Polyurethane	30	0.030	1380	26
Glass fibre	30	0.035	800	52

ACOUSTIC PROPERTIES

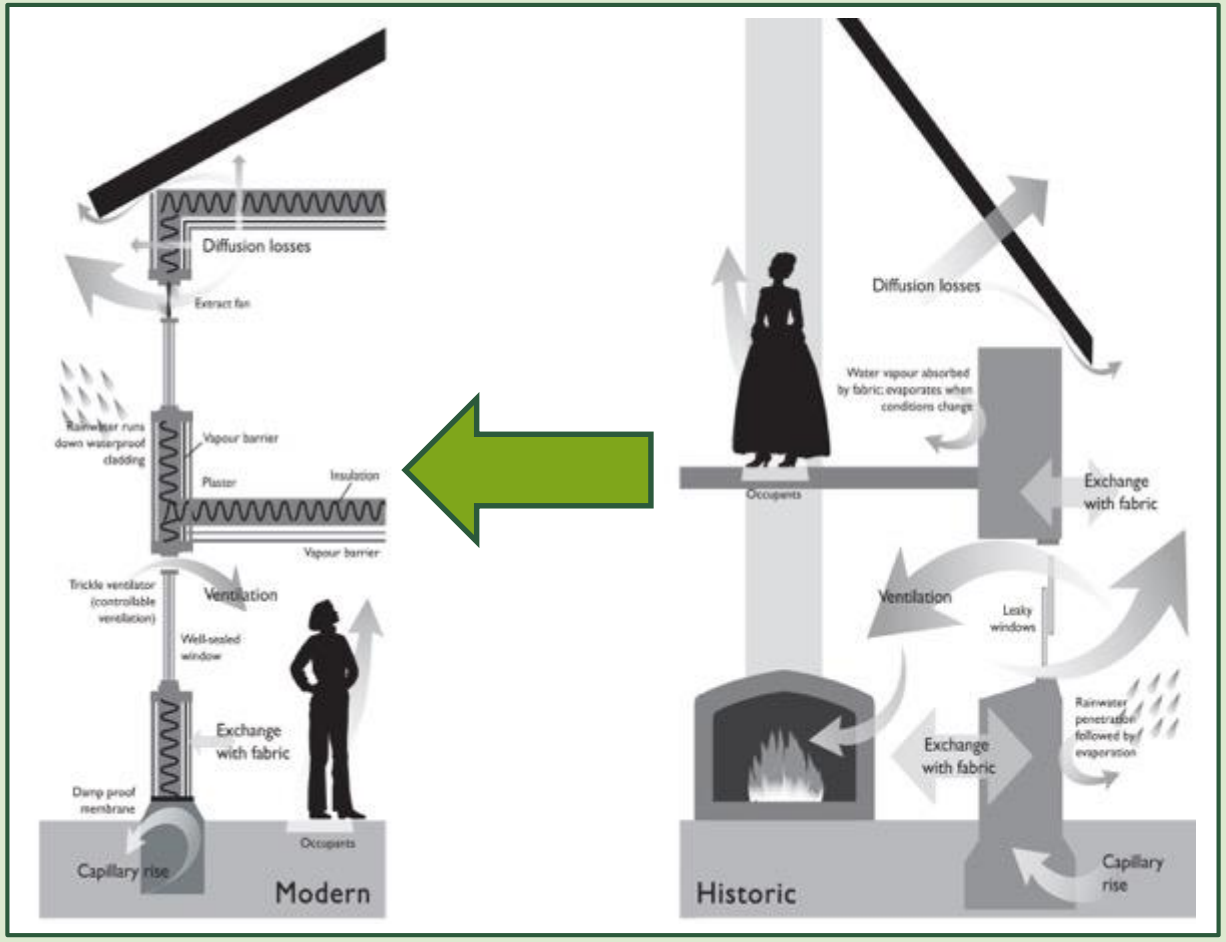
- Airborne sound reduction (density and porosity)
- Excellent internal acoustics (reverberation reduction)
- Impact sound reduction (dynamic stiffness)

COMFORTABLE & HEALTHY INTERNAL ENVIRONMENT

Insulation (as a key component of the building fabric) should support a comfortable, healthy internal environment:

- Thermal comfort (overheating protection and low temperature fluctuations)
- Healthy indoor air (volatile organic compounds and airborne particulates)
- Acoustic comfort
- Psychological wellbeing (biophilia)
- Moisture comfort (healthy humidity levels)

MOISTURE IN BUILDINGS



(R. Pender in EH, 2010)

Impact on moisture movement is the most important consequence for the health of both occupants and building fabric.

Resulting in unintended consequences….

Upgrading the energy efficiency of buildings radically alters their hygrothermal dynamics.

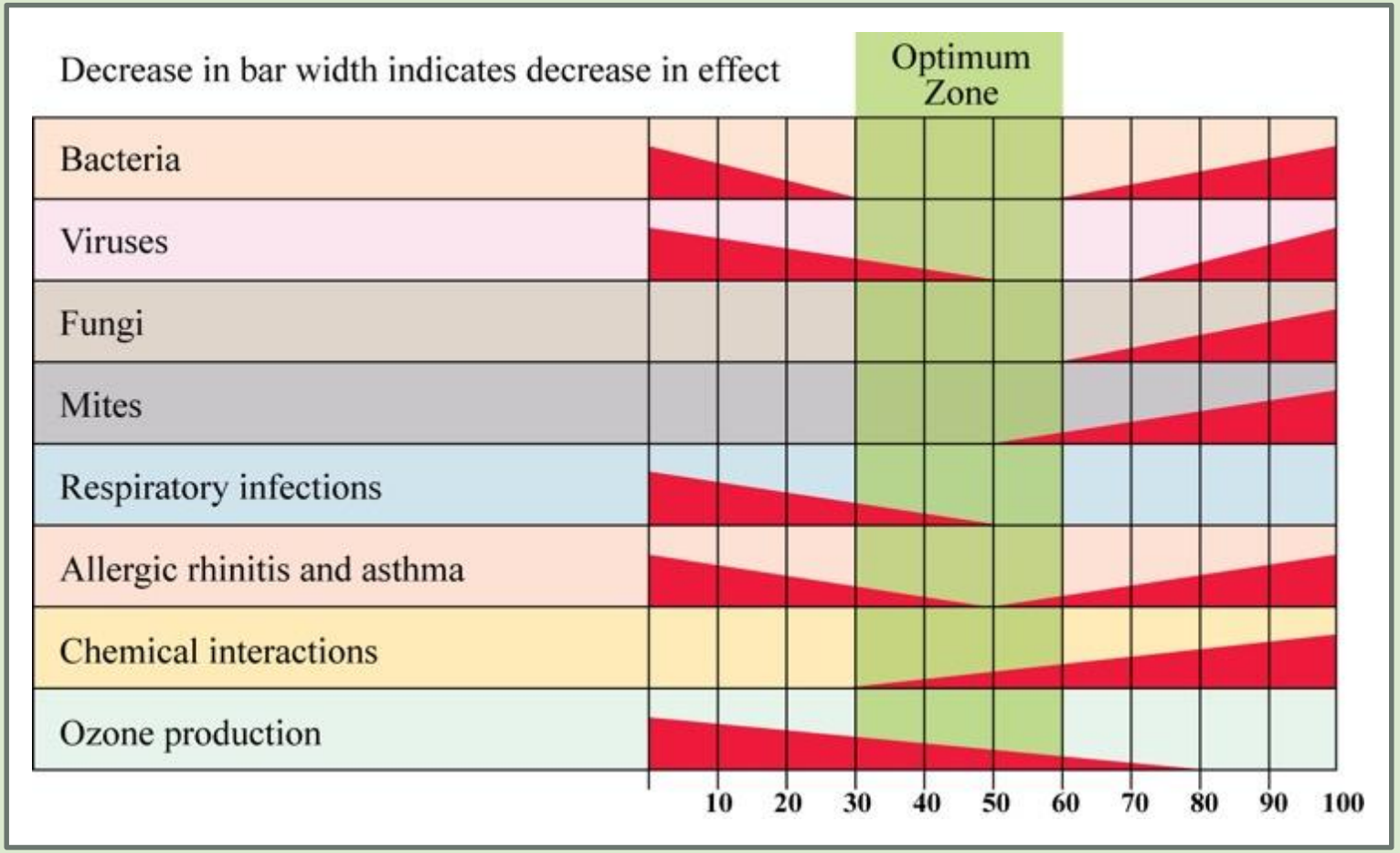
NATURAL FIBRE INSULATION GROUP

OCCUPANCY RELATED WATER VAPOUR CONTRIBUTION TO INTERNAL AIR

Example of a typical three-bedroom family house:

Activity	Litres moisture per day
A family asleep	1.5 - 2.0
Typical daytime activities	2.5 - 3.5
Cooking	2.0 - 3.5
Washing and bathing	1.0 - 1.5
Washing clothes	0.4 - 0.6
Drying clothes	3.0 - 5.0
Approx. Total	9 - 15 ltrs

RELATIVE HUMIDITY CONTROL

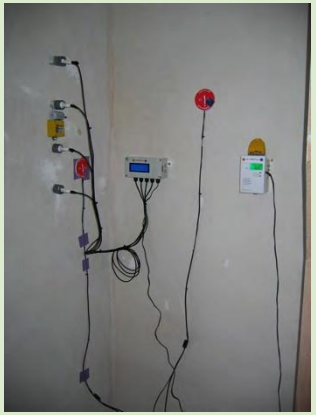


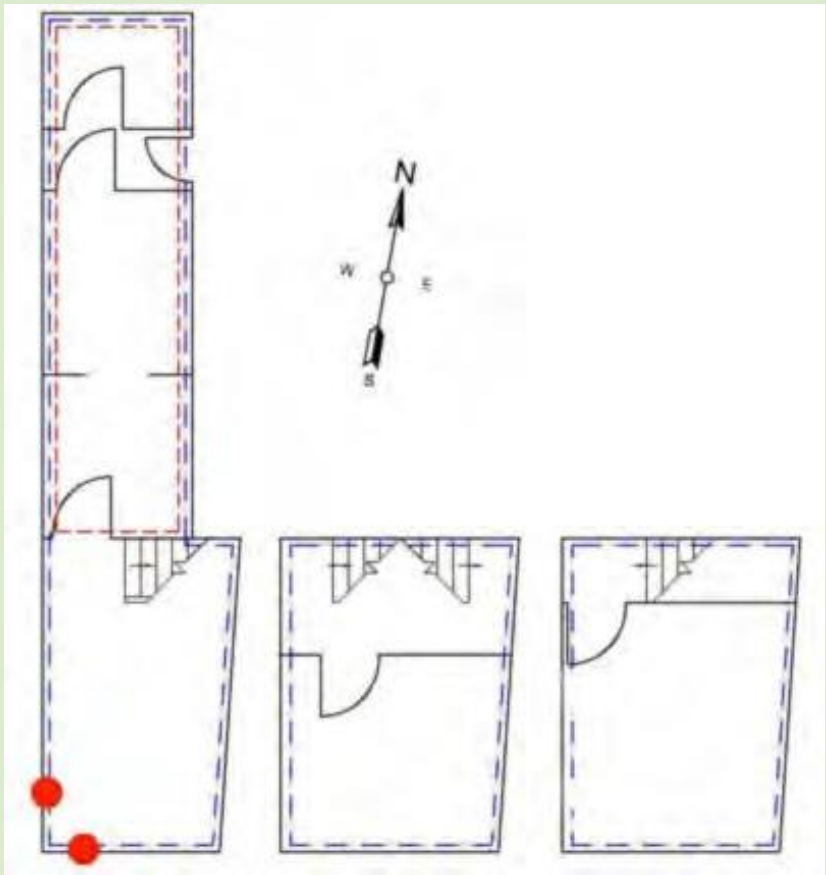
SPAB TESTING

During 2009-2010 the SPAB started an investigation into the thermal performance of historic buildings.

This testing fitted in with our own testing of internal wall insulation.

Plan of 116 Abbey Foregate, Shrewsbury, with ground floor on left hand side.



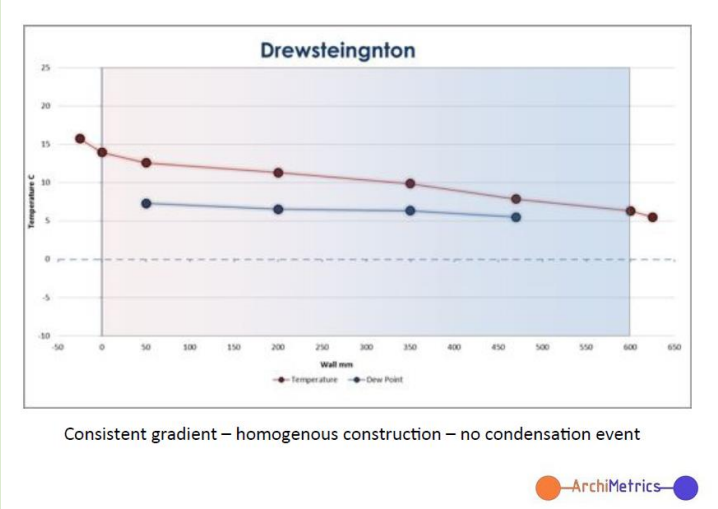


IN SITU INTERSTITIAL CONDENSATION & DEW POINT ANALYSIS

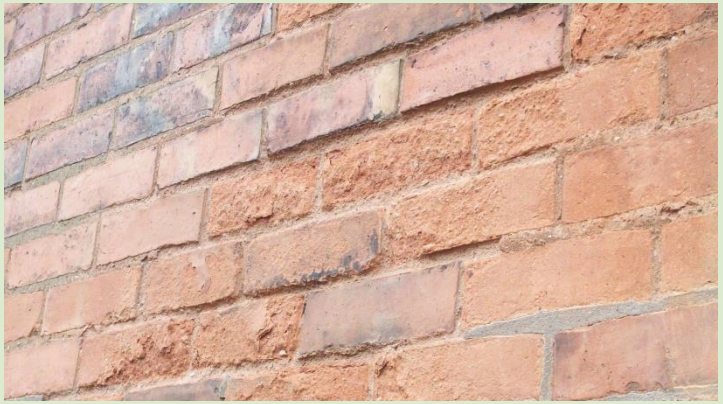
Current modelled dew point analysis normally show a condensation occurrence with solid walls, however testing by Archimetrics show that this is rare.

Adding to much internal insulation and non vapour permeable types can cause damage to bricks and embedded timbers

60-80mm of wood fibre insulation onto 9” brick walls is about right. Target U value 0.6 W/m2k.



Consistent gradient – homogenous construction – no condensation event



REAL RETROFITS – BRICK WALL -IWI

Thickness not 220mm but 345mm -- a brick and a half --
Insulated with 40mm woodfibre – 8mm lime plaster -- without a VCL

U--value -- Brick	Uninsulated	Insulated	% Reduction
Measured	1.48 W/m^{2}K	0.48 W/m^{2}K	68%
Calculated	1.52 W/m^{2}K	0.52 W/m^{2}K	66%
Targets	SAP = 2.1	Part L = 0.30	86%

NATURAL FIBRE INSULATION GROUP

HEALTH & SAFETY IN USE AND DURING INSTALLATION

Handling
All natural fibre insulation products are safe for installers – they do not irritate the skin, eyes or respiratory tract

Fire Safety
All insulations should support fire safe construction
Performance tests include: surface spread of flame, ignitability, rate of combustion, smoulder resistance, type of combustion products (gases)

Click to see STEICO fire test video

SUSTAINABILITY

- Raw material sustainability (abundant / continuously renewable)
- Healthy (in both production as well as use)
- Low embodied carbon
- End of-life (re-use, composting or incineration)
- Transparency (Environmental Product Declaration / Ecolabel

CONCLUSIONS

AN INTRODUCTION TO NATURAL FIBRE INSULATION

CONCLUSIONS

- The choice of insulation product or system radically influences building performance (it's not just about thermal conductivity)
- Natural insulations are appropriate to a wide range of building types and building elements
- Natural insulations can be the most cost effective solution

If you wish to explore the costs and benefits of moving to a natural insulation solution please contact us or one of our NFIG members.

NATURAL FIBRE INSULATION GROUP

THANKS

ASBP The Alliance for Sustainable Building Products

NATURAL FIBRE INSULATION GROUP

asbp.org.uk/natural-fibre-insulation-group

info@asbp.org.uk

@asbp_uk